

BAR PRESS AND BAR RELEASE AS AVOIDANCE RESPONSES¹

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Two experiments were performed in which rats had to avoid shock by both pressing and releasing a bar within specified intervals. When the release-shock interval was held constant and the press-shock interval was increased, response rate decreased and bar holding increased. When the press-shock interval was held constant and the release-shock interval was increased, both response rate and bar holding decreased.

Key words: avoidance, shock, response duration, interresponse time, freezing, bar press, rats

Since Meyer, Cho, and Weseman (1960) described the difficulties they encountered in conditioning rats to press a bar to avoid shock, there have been many similar reports. Bolles (1972) has reviewed this literature and described the problems which have been encountered. The major difficulty has been the rats' tendency to freeze. Rats adopt a hunched position and remain immobile until shocked, at which time they press the bar (e.g., Bolles & Popp, 1964). In many experiments in our laboratory, we found that rats which were freezing in this way were actually holding the bar between shocks and that the bar press which was recorded following each shock was just a consequence of shock-elicited flinching. Other experimenters observed the same behavior, and several attempts have been made to facilitate the acquisition of bar-press avoidance by reducing bar holding. For example, Feldman and Bremner (1963) shocked the rats in their experiment after they had held the bar for some unspecified period of time and reported good avoidance conditioning.

Other studies examined the effect of shocking rats for bar holding during both the acquisition and maintenance of avoidance. Keehn (1967) conditioned subjects to press or release the bar in the presence of different preshock stimuli. He defined the press-shock interval as the time between pressing the bar and receiving shock for failing to release it. The

release-shock interval was defined as the time between releasing the bar and receiving shock for failing to press it. Two durations of each interval were used and the duration of both intervals was changed simultaneously. Keehn reported that the rats held the bar for longer periods of time when the press-shock interval was longer than the release-shock interval. Meltzer (1968) kept both the press-shock and release-shock intervals constant at 20 sec and found that the rats held the bar for more than half the session. Hurwitz (1967) did not shock rats for holding the bar, but he did record bar-holding behavior during continuous avoidance in which only bar presses were counted as avoidance responses. The rats held the bar for most of the session regardless of the length of the response-shock interval.

Another group of studies did not attempt to eliminate bar holding. Instead, the experimenters allowed the rats to avoid all shocks when they were holding the bar down. Walsh and Keehn (1969) used this procedure and shocked the rat after the bar had been released for a fixed period of time. They found that bar holding decreased as the release-shock interval increased. Keehn and Walsh (1970) studied bar holding during both escape and avoidance conditioning. In their avoidance experiment, a subject could avoid or escape by pressing the bar, and the subject was never shocked while the bar was held. In their escape experiment, the subject could not avoid shock but could escape by pressing the bar. The rats held the bar for longer durations during avoidance than during escape conditioning.

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Davis and Burton (1976) also compared bar holding during escape and avoidance and showed that when rats could avoid shock by holding the bar, they did so for almost the entire session.

It is apparent that bar holding is a common response by rats during avoidance conditioning. What is not clear is whether bar-holding behavior is affected by contingencies applied to the bar press, or whether bar-holding behavior can be controlled only by contingencies applied to bar release. Moreover, there is no indication of whether there is any effect on the time between bar release and the next bar press when contingencies are applied to bar release. The current experiments were performed to determine the effect of avoidance contingencies applied to both bar press and bar release and to see what effect each contingency had on the duration of bar-holding behavior.

EXPERIMENT 1

METHOD

Subjects

Six male Long-Evans hooded rats which were bred in the university animal colony served. They were approximately 120 days old at the beginning of the experiment and were experimentally naive.

Apparatus

Two identical experimental chambers were used. Each chamber (Lehigh Valley model 1417) had interior dimensions of 21.0 cm by 30.5 cm by 18.0 cm. A lever was mounted 2.5 cm above the grid floor at the midline of the front wall. There was a cue light 3 cm above the lever which emitted 30.9 mW (98.35

cd/m²). Both chambers were in sound-attenuated, ventilated enclosures, and white noise was always present in the experimental room. Programming and recording equipment were in an adjacent room. Scrambled constant current shock was delivered to the grid floor by a shock generator (Lehigh Valley model 1531).

Procedure

Each experimental session lasted 90 min, and sessions were scheduled 5 days a week. There were two different avoidance contingencies. Figure 1 illustrates the procedure. If the rat failed to press the bar within 15 sec after releasing it, a .4-sec, 1-ma shock was delivered. The shock was repeated at 1-sec intervals until the rat pressed the bar. If the bar was pressed and held in the down position, the next shock was delayed for 15 sec. At that time, a .4-sec, 1-ma shock was delivered and was repeated at 1-sec intervals until the rat released the bar. Thus, there was one contingency termed the press-shock interval: the time between pressing the bar and delivery of a shock unless the bar was released. A second contingency was called the release-shock interval: the time between releasing the bar and delivery of a shock unless the bar was pressed. The cue light above the bar was on as long as the subject held the bar down. This procedure was maintained for 13 sessions and the data described were gathered during the next 21 sessions. The release-shock interval continued at 15 sec for the rest of the experiment.

Beginning with the 14th session, the duration of the press-shock interval was changed after blocks of seven sessions. There were three such blocks for a total of 21 sessions.

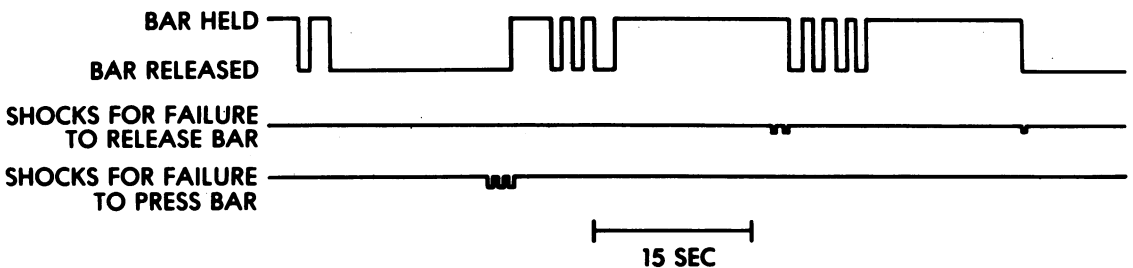


Fig. 1. This figure illustrates part of an experimental session in which both the press-shock and release-shock intervals were 15 sec. The timer controlling the press-shock interval began as soon as the bar was pressed and did not run while the bar was released. The time controlling the release-shock interval began as soon as the bar was released and did not run while the bar was held.

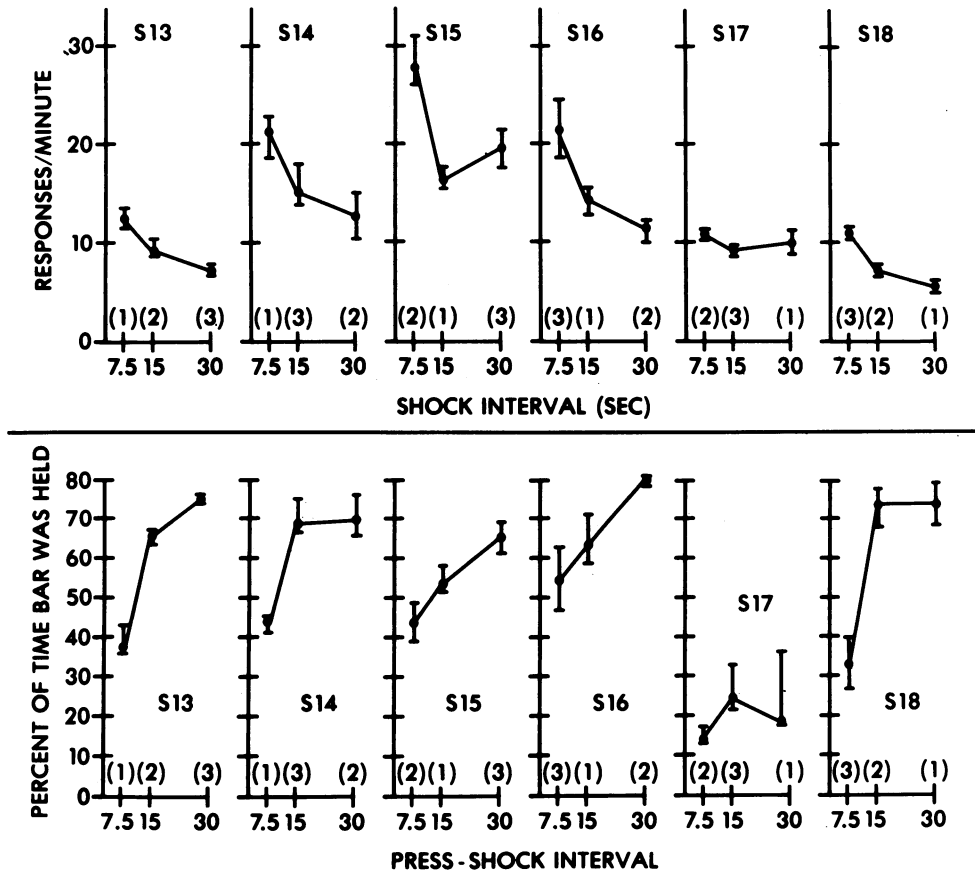


Fig. 2. The median and range of response rates during the last four sessions at each setting of the press-shock interval are shown in the upper panels. The median percentage and percentage range of session time during which subjects held the bar in the same sessions are shown in the lower panels. The numbers in parentheses above the horizontal axes show the order in which the different press-shock intervals were presented.

Subject S13 had press-shock intervals of 7.5, 15, and 30 sec in successive blocks of sessions. Subject S14 had successive press-shock intervals of 7.5, 30, and 15 sec. For S15 the sequence was 15, 7.5, and 30 sec; for S16 the sequence was 15, 30, and 7.5 sec; for S17 the sequence was 30, 7.5, and 15 sec; and for S18 the sequence was 30, 15, and 7.5 sec.

The total number of bar presses was recorded for each subject in each session. In addition, the total time during which the bar was held and the total time during which it was released was recorded. And finally, a separate record was kept of the shocks which each subject received for failing to press the bar and the shocks which it received for failing to release the bar.

RESULTS

The upper panel of Figure 2 shows each subject's median response rate during the last

four sessions at each of the different values of the press-shock interval as well as the range of those rates. All the subjects responded at lower rates when the press-shock interval was 15 sec than when it was 7.5 sec. However, two of the rats, S15 and S17, had higher median response rates when the press-shock interval was 30 sec than when it was 15 sec. Apparently increases in the press-shock interval usually resulted in decreases in median response rate, but the question of greatest interest was how increases in the press-shock interval affected bar holding. The bottom panel of Figure 2 shows the median percentage of session time during which the bar was held (as well as the range of percentages) during the last four sessions at each press-shock interval. All the rats held the bar for a larger percentage of session time when the press-shock interval was 15 sec than when it was 7.5 sec. Four of the six subjects also had longer median percentages of hold-

ing time when the press-shock interval was 30 sec than when it was 15 sec. But S17 actually held the bar for a shorter median percentage of session time, and S18 held it for approximately the same percentage of time in each case. In addition, the increase in percentage holding time was quite small for S14.

When the time during which the bar was held was divided by the number of responses in a session, the result was the mean hold duration—the mean time from press to release. When the time during which the bar was not held was divided by the number of responses, the result was the mean release duration—the mean time from release to press. Thus, an increase in mean hold duration may have occurred because response rate decreased while holding time remained constant, because response rate remained constant while holding time increased, because response rate decreased and holding time increased, or even because response rate decreased to a greater degree

than holding time. Mean release duration may have increased, decreased, or remained unchanged when hold duration increased. For example, if holding time (and release time) remained constant while response rate decreased, both mean hold duration and mean release duration increased. If response rate remained constant while holding time increased, mean hold duration would have increased while mean release duration would have decreased. If response rate decreased while holding time increased, mean hold duration would have increased; but that would have meant that the subject held the bar for less time, and since response rate had also decreased, mean release duration would have been unaffected.

Figure 3 shows the median measures of hold duration and release duration along with ranges during the last four sessions at each press-shock interval. Each subject had longer median hold durations when the press-shock

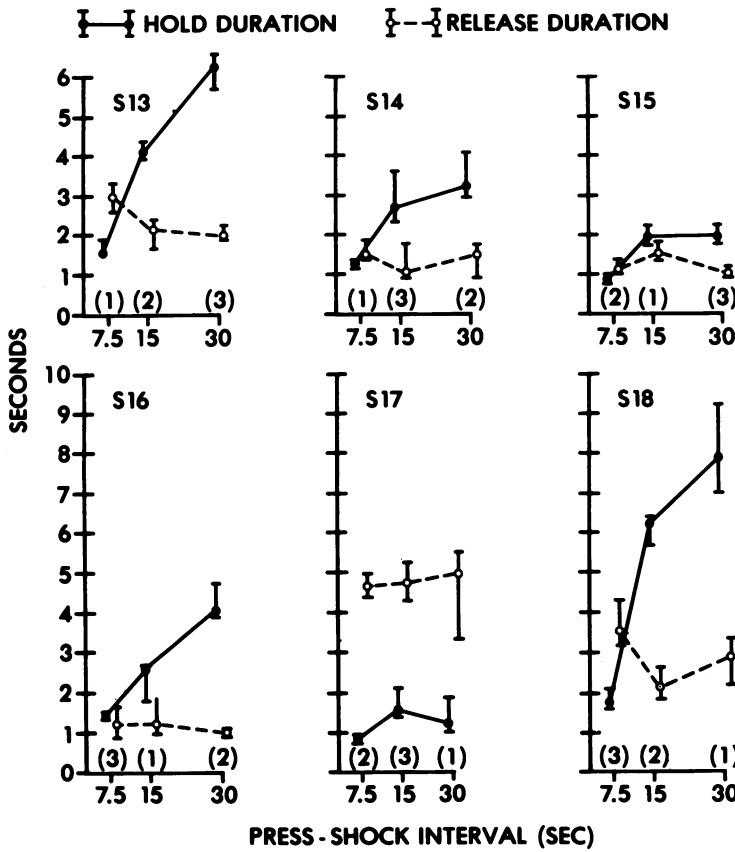


Fig. 3. The median and range of each subject's hold duration and release duration are shown. The data are taken from the last four sessions at each value of the press-shock interval. The numbers in parentheses above the horizontal axes show the order in which the different press-shock intervals were presented.

interval was 15 sec than when it was 7.5 sec. Four of the subjects also had longer median hold durations when the press-shock interval was 30 sec than when it was 15 sec. Subject S15 had approximately the same median hold duration at 15 and 30 sec, and S17 had a shorter median hold duration when the press-shock interval was 30 sec. There was no consistent relationship between the length of the press-shock interval and the median release duration. It may also be seen that when the press-shock interval was 7.5 sec, five of the six rats had longer median release durations than median hold durations. When the press-shock interval was 15 sec or 30 sec, five of the six rats had longer median hold durations.

Another question concerned the effect of different press-shock intervals on the efficiency of avoidance. The assumed maximum shock frequency for holding the bar was 8 shocks/min when the press-shock interval was 7.5 sec, 4 shocks/min when the press-shock interval was 15 sec, and 2 shocks/min when the press-shock interval was 30 sec. As Table 1 shows, the median percentage of those hold shocks which subjects avoided was very similar during the last four sessions at the different press-shock intervals. Table 1 also shows that the percentage of shocks avoided by pressing and releasing the bar was usually very similar. That held true even when the press-shock and release-shock intervals were different. However, all the rats except S14 and S15 avoided a higher median percentage of the hold shocks when the press-shock interval was 15 sec as compared to 7.5 sec.

The maximum possible shock frequency for failing to release the bar was 4 shocks per min throughout the experiment since the release-shock interval was always 15 sec. Table 1 also shows that the percentage of release shocks which subjects avoided was unrelated to the length of the press-shock interval.

Examination of the data showed a warm-up effect for some subjects, especially when the press-shock interval was 7.5 or 15 sec, but warm-up was not consistent across all subjects or even in the same subject at different stages of the experiment.

EXPERIMENT 2

Since it had been shown that increases in the press-shock interval reduced response rate

Table 1

The median percentage of shocks avoided during the last four sessions at each press-shock interval is shown below. Hold shocks were avoided by releasing the bar before the end of the press-shock interval. Release shocks were avoided by pressing the bar before the end of the release-shock interval.

| Subject | Press-shock interval (sec) | Order of presentation | Median percentage of hold shocks avoided | Median percentage of release shocks avoided |
|---------|----------------------------|-----------------------|--|---|
| S13 | 7.5 | 1 | 55.7 | 75.6 |
| | 15 | 2 | 85.6 | 82.4 |
| | 30 | 3 | 79.6 | 79.0 |
| S14 | 7.5 | 1 | 95.2 | 96.0 |
| | 15 | 3 | 94.8 | 94.9 |
| | 30 | 2 | 96.8 | 94.3 |
| S15 | 7.5 | 2 | 97.7 | 89.7 |
| | 15 | 1 | 97.0 | 90.2 |
| | 30 | 3 | 98.8 | 91.2 |
| S16 | 7.5 | 3 | 91.1 | 84.8 |
| | 15 | 1 | 95.0 | 86.2 |
| | 30 | 2 | 90.7 | 88.3 |
| S17 | 7.5 | 2 | 87.8 | 93.7 |
| | 15 | 3 | 97.0 | 91.4 |
| | 30 | 1 | 95.0 | 90.1 |
| S18 | 7.5 | 3 | 78.4 | 84.8 |
| | 15 | 2 | 87.0 | 91.7 |
| | 30 | 1 | 89.4 | 87.4 |

while increasing bar holding, this experiment was performed to see whether increases in the release-shock interval would reduce response rate while decreasing bar holding.

METHOD

Subjects

Six male Long-Evans hooded rats which were bred in the university animal colony served. They were approximately 120 days old at the beginning of the experiment and were experimentally naive.

Apparatus

The apparatus was identical to that used in the first experiment.

Procedure

During the first 13 sessions, the procedure was identical to the procedure employed in the first experiment. The main difference between the two studies was that in Experiment 1, the press-shock interval was varied while the release-shock interval remained 15 sec during the last 21 sessions. In Experiment 2, the re-

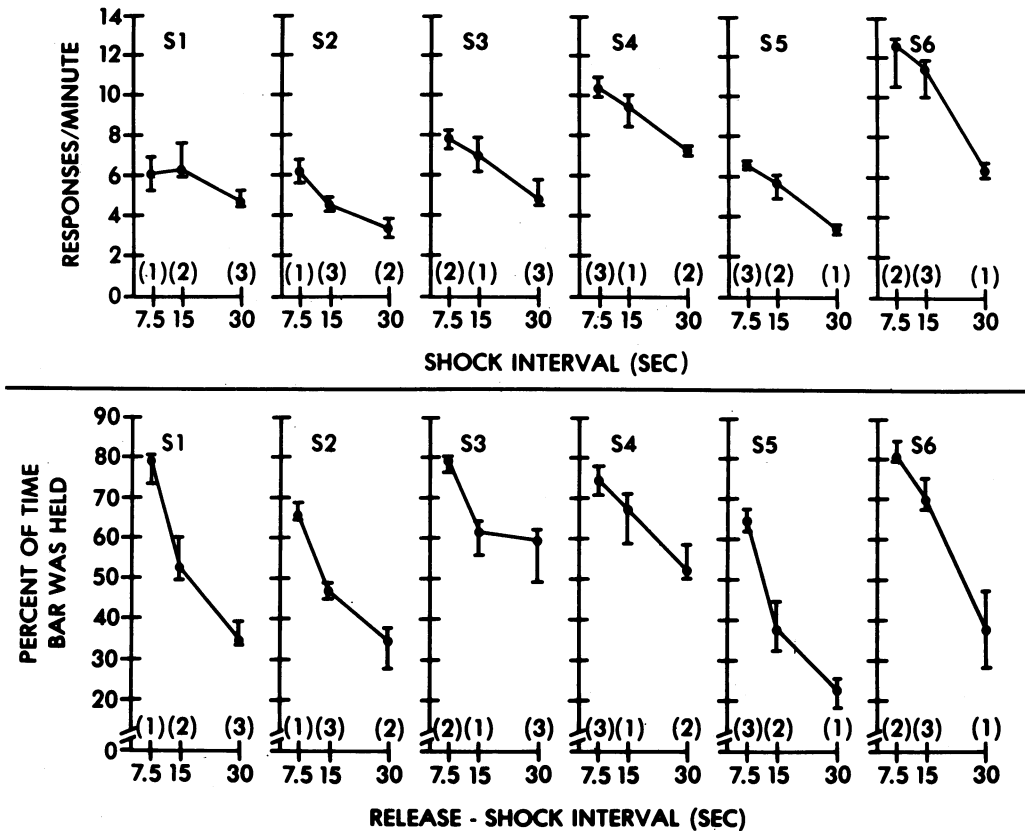


Fig. 4. The median and range of response rates during the last four sessions at each setting of the release-shock interval are shown in the upper panels. The median percentage and percentage range of session time during which subjects held the bar in the same sessions are shown in the lower panels. The numbers in parentheses above the horizontal axes show the order in which the different release-shock intervals were presented.

verse was true—during the last 21 sessions, the release-shock interval was varied and the press-shock interval continued at 15 sec.

The release-shock interval was 15 sec for all six subjects during the first 13 sessions. Beginning with the 14th session, the release-shock interval was changed after every block of seven sessions. Subject S1 had release-shock intervals of 7.5, 15, and 30 sec in successive blocks of sessions. Subject S2 had successive blocks with release-shock intervals of 7.5, 30, and 15 sec. For S3 the sequence was 15, 7.5, and 30 sec; for S4 it was 15, 30, and 7.5 sec; for S5 it was 30, 15, and 7.5 sec; and for S6, 30, 7.5, and 15 sec.

The shock parameters were the same as those used in the first experiment and the shock-shock interval remained at 1 sec.

RESULTS

The upper panel of Figure 4 shows each subject's median response rate and the range

of response rates during the last four sessions at each value of the release-shock interval. The lower panel of the same figure shows the median percentage of session time during which the bar was held and the range of percentages during those same sessions. It is clear that as the release-shock interval increased, median response rates decreased. The only exception to this general statement was S1, which responded at a slightly higher median rate when the release-shock interval was 15 sec than when it was 7.5 sec. The bottom panel shows that these decreases in response rate were accompanied by a decrease in the median percentage time during which the bar was held. The only exception to the last statement was that S3 held the bar for approximately the same median percentage of session time when the release-shock interval was 15 and 30 sec.

These data were also used to compute mean hold durations and mean-release durations

just as in the first experiment. Figure 5 shows the median value and range of both of these measures during the last four sessions at each of the release-shock intervals. As was expected, every subject had a longer median release duration when the release-shock interval was 15 sec than when it was 7.5 sec and a longer release duration when the release-shock interval was 30 sec than when it was 15 sec. Hold durations did not show any consistent pattern as the release-shock interval increased. Figure 5 also shows that when the release-shock interval was 7.5 sec, all six subjects had median hold durations which were longer than their median release durations. When the release-shock interval was 15 sec, four subjects had longer hold durations; and when the release-shock interval was 30 sec, only two subjects had longer hold durations. In the case of these last two subjects, S3 and S4, the difference between hold and release durations

was much smaller when the release-shock interval was 30 sec than when it was 7.5 sec.

Table 2 shows the median percentage of hold shocks and release shocks which each subject avoided at the different values of the release-shock interval. No consistent relationship between the percent of shocks avoided and the duration of the release-shock interval is apparent for either measure. As in Experiment 1, the percentage of shocks a subject avoided by pressing and releasing the bar was usually similar even when the press-shock and release-shock intervals were different.

Warm-up effects were more common in this procedure than in the first experiment but were not always consistent. The usual pattern was a high shock frequency during the first 5 to 10 min of a session which was reduced to a stable shock frequency after approximately 15 min. However, the length of the warm-up period, the number of shocks the

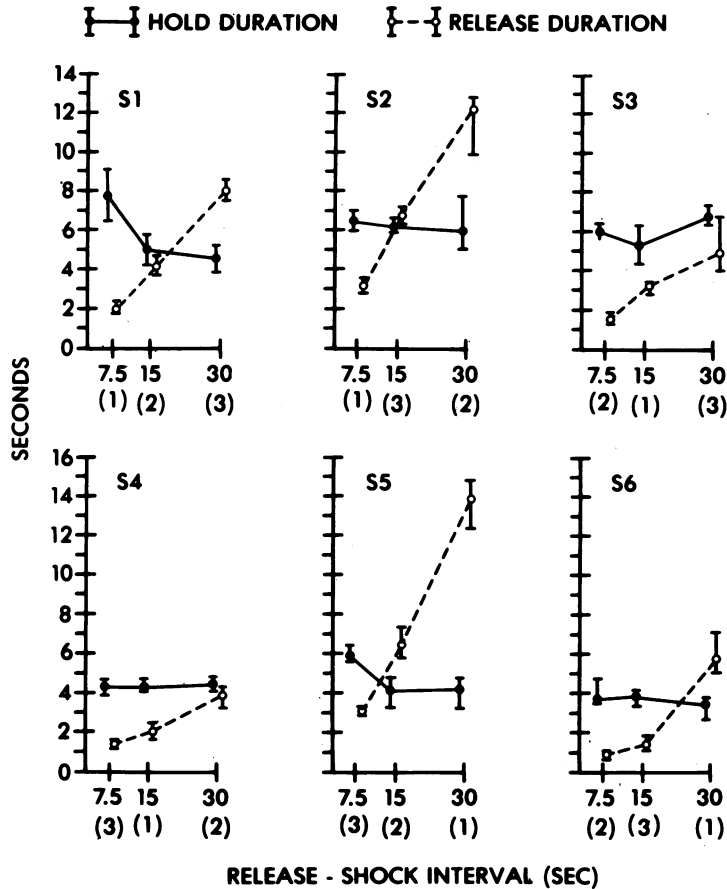


Fig. 5. The median and range of each subject's hold duration and release duration are shown. The data are taken from the last four sessions at each value of the release-shock interval. The numbers in parentheses below the horizontal axes show the order in which the different press-shock intervals were presented.

Table 2

The median percentage of shocks avoided during the last four sessions at each release-shock interval is shown below. Hold shocks were avoided by releasing the bar before the end of the press-shock interval. Release shocks were avoided by pressing the bar before the end of the release-shock interval.

| Subject | Release-shock interval (sec) | Order of presentation | Median percentage of hold shocks avoided | Median percentage of release shocks avoided |
|---------|------------------------------|-----------------------|--|---|
| S1 | 7.5 | 1 | 75.7 | 83.1 |
| | 15 | 2 | 84.1 | 87.1 |
| | 30 | 3 | 80.1 | 81.5 |
| S2 | 7.5 | 1 | 65.3 | 73.7 |
| | 15 | 3 | 56.8 | 63.4 |
| | 30 | 2 | 67.8 | 63.8 |
| S3 | 7.5 | 2 | 82.2 | 75.8 |
| | 15 | 1 | 85.6 | 78.7 |
| | 30 | 3 | 80.8 | 76.7 |
| S4 | 7.5 | 3 | 90.5 | 77.8 |
| | 15 | 1 | 92.5 | 88.6 |
| | 30 | 2 | 91.3 | 89.1 |
| S5 | 7.5 | 3 | 73.5 | 84.8 |
| | 15 | 2 | 72.6 | 91.0 |
| | 30 | 1 | 93.1 | 90.3 |
| S6 | 7.5 | 2 | 49.9 | 70.8 |
| | 15 | 3 | 80.2 | 75.0 |
| | 30 | 1 | 87.6 | 81.5 |

subject received, and even the occurrence of a warm-up period varied widely between subjects and within the same subjects at different stages of the experiment.

DISCUSSION

The results of these experiments are easily summarized. An increase in the press-shock interval while the release-shock interval remained constant led to a decrease in response rate and an increase in bar holding. An increase in the release-shock interval while the press-shock interval remained constant led to a decrease in response rate and a decrease in bar holding. The question to be answered is why these differences in bar-holding behavior occurred. Consider first the situation in which the press-shock interval was longer than the release-shock interval. When the subject pressed the bar, it initiated the press-shock interval and thereby delayed shock for a longer period of time than when it released the bar. If subjects were free to choose between bar press and bar release, one would expect them to emit

more bar-press responses, but there was no such freedom. Bar press and bar release had to alternate. Since the subject could not press the bar more often than it released the bar, the time spent in the shorter shock delay condition could be minimized only by bar holding. The proportion of session time during which the bar could be held was limited by the requirement that subjects release the bar before the end of the press-shock interval. Apparently the subjects responded to these contingencies by holding the bar long enough so that they avoided approximately the same percentage of shocks scheduled by the release-shock and the press-shock intervals.

When the release-shock interval was longer than the press-shock interval, the situation was reversed. Rats would receive fewer shocks by remaining off the bar for most of the session, and that is generally what they did.

These results are important because of what they imply about the conventional continuous avoidance procedure in which only the bar press serves as an avoidance response. In such an experiment, the rat would sometimes be shocked while holding the bar, at other times shortly after having released the bar, and at still others long after having released the bar. The only consistent relationship would be the time between pressing and shock. The rat would find itself in a situation in which no contingencies were applied to bar release and in which the temporal relationship between bar release and shock was unpredictable. That unpredictability may be a major factor in the difficulty so often encountered in conditioning rats to press a bar during continuous avoidance experiments. Such an interpretation is supported by Feldman and Bremner's (1963) successful shaping of bar-press avoidance by shocking rats for holding the bar.

In addition, these experiments illustrate the persistence of bar holding even in those rats which do learn to avoid. All 12 subjects in these two studies were exposed to avoidance schedules in which both the press-shock and the release-shock intervals were 15 sec. As Figures 2 and 5 showed, 9 of the 12 rats held the bar more than half the time during those sessions. Meltzer (1968) also found that rats held the bar more than they were off it when the press-shock interval equaled the release-shock interval. Hurwitz (1967) reported that rats held the bar for more than half the ses-

sions when only a bar press avoided shock. All these results show that bar holding is not an impediment to successful avoidance performance. In fact, it appears that bar holding is an integral part of the behavior of those rats which learn to avoid. If modifications of the standard procedure are called for, such modifications should involve an attempt to record and control bar-holding behavior rather than an attempt to eliminate it.

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Received January 30, 1978

Final acceptance November 7, 1978